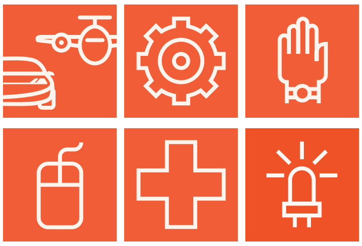
Details on lead-free reflow soldering of LEDs

Application Note

Published by ams-OSRAM AG
Tobelbader Strasse 30,
8141 Premstaetten Austria
Phone +43 3136 500-0
ams-osram.com

Details on lead-free reflow soldering of LEDs

Application Note No. AN021



Valid for:
all SMD LEDs

Abstract

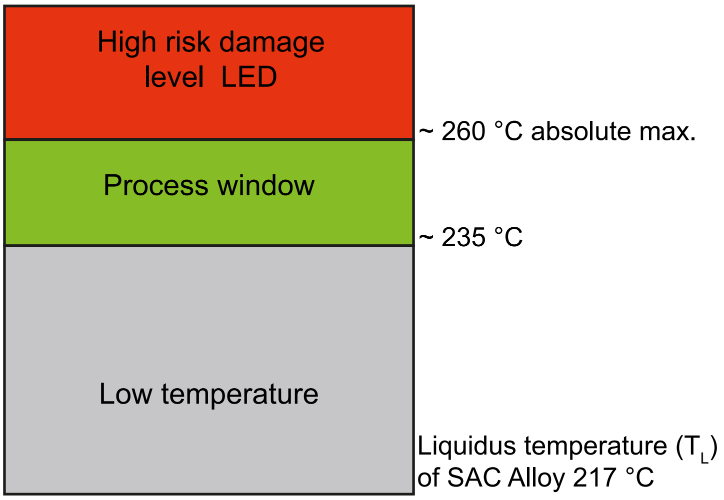
Lead-free reflow soldering of LEDs requires precise thermal control to ensure reliable electrical and mechanical connections. This document outlines key process parameters based on JEDEC J-STD 020F, including temperature limits, ramp rates, and time above liquidus. It provides guidance for creating a stable temperature profile. Particular attention is paid to preventing thermally induced damage to assemblies and PCB substrates. Additional techniques like vacuum and vapor-phase soldering are discussed.

Table of contents

1 Basics of the soldering process

Reflow soldering means a previously applied solder deposit (solder paste) is melted in an oven using a controlled process. The assembly is heated as evenly as possible using circulating hot air or nitrogen. Most lead-free alloys require higher melting temperatures than those containing lead. This results in a very narrow process window between solder melting and component damage, as shown in Figure 1. The goal is to achieve uniform heating with a minimum temperature difference (ΔT). Using a suitable and precisely fine-tuned temperature profile minimizes the risk of components being damaged by thermal stress.

Figure 1: Process window of lead-free alloys



1.1 JEDEC standard J-STD 020F

The IPC/JEDEC standard J-STD 020F “Moisture/Reflow Sensitivity Classification for Nonhermetic Surface Mount Devices” is the primary basis and reference for reflow soldering of SMDs with plastic or other moisture-permeable housings - a category that also includes LEDs. It provides relevant characteristic data and general limit values (Table 1), including the basic temperature-time characteristics (= Temperature-profile) for the reflow soldering process (Figure 2).

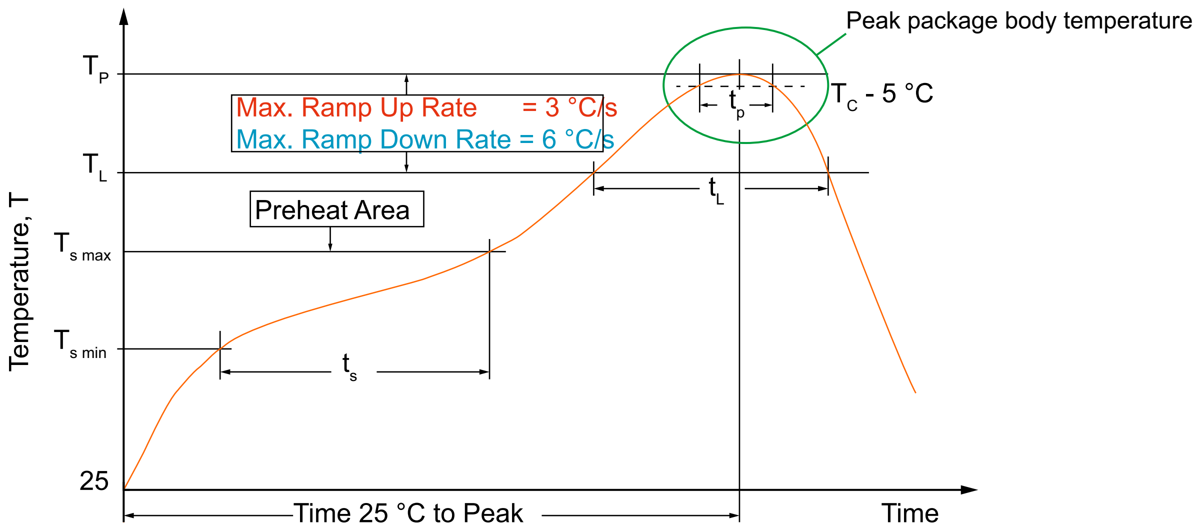
Table 1: Relevant key data and limits for the reflow soldering profile

Profile property	Lead-free processing limits
Preheat / soak Temperature min ($T_{S\ min}$) Temperature max ($T_{S\ max}$) Time (t_S) from T_S min to T_S max	 150 °C 200 °C max. 120 seconds
Ramp-up rate (T_L to T_P)	3 °C / second max.
Liquidus temperature (T_L) Time (t_L) maintained above T_L	217 °C max. 150 seconds
Peak package body temperature (T_P)[1]	For users, T_P must not exceed the classification temperature T_C For suppliers, T_P must equal or exceed the classification temp T_C
Time (t_P)[1] within 5 °C of the specified classification temperature (T_C)	max. 30 seconds
Ramp-down rate (T_P to T_L)	6 °C / Second max.
Time 25 °C to peak temperature	8 minutes max

[1] Tolerance for peak profile temperature (T_P) is defined as a supplier minimum and a user maximum

[2] Tolerance for the time at peak profile temperature (t_P) is defined as a supplier minimum and a user maximum

Figure 2: General classification of a temperature-profile for reflow soldering according to J-STD 020F



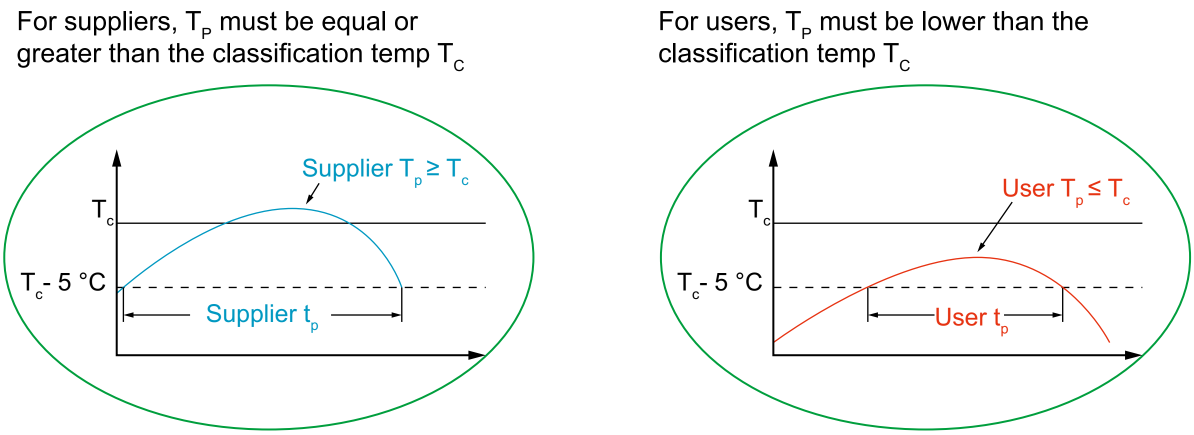
The most important aspect is the determination of the maximum permissible temperature in dependence of the housing thickness and the component volume (Table 2). The classification temperature T_C refers to the case temperature measured at the top of the component. **Up to this temperature T_C, the component is qualified by the manufacturer, ensuring process capability at the specified moisture sensitivity level.**

Table 2: Classification temperature T_C depending on the package volume for lead-free processing (according to J-STD-020F)

Package thickness	Volume in mm³ < 350	Volume in mm³ 350 - 2000	Volume in mm³ > 2000
< 1.6 mm	260 °C	260 °C	260 °C
1.6 mm - 2.5 mm	260 °C	250 °C	245 °C
> 2.5 mm	250 °C	245 °C	245 °C

According to JEDEC standard J-STD 020F, the package temperature is defined as “Peak Package Body Temperature” (T_P), often also referred to as “Package Reflow Temperature.” (It should not be misunderstood that “reflow” refers to the temperature of the solder joint.) This temperature must be greater than or equal to T_C for the device supplier, but for a user, this must not be exceeded. Figure 3 illustrates this. Here, the T_P has been extracted from the general classification in Figure 2 and shows once the requirements for the supplier and once for the user.

Figure 3: Peak Package Body Temperature T_P



Further information on the precise measurement of package temperature can be found in JEP 140. The JEDEC standard J-STD 020F also stipulates that all temperatures must be referenced to the center of the housing and that measurements must be taken on the housing surfaces that face upwards during soldering (“live bug”).

“All ramp rates (up or down) shall be calculated as an average rate over a five second period....” (IPC/JEDEC J-STD 020F “Moisture/Reflow Sensitivity Classification for Nonhermetic Surface Mount Devices”, p. 12)

The JEDEC standard J-STD 020F also contains general requirements and limit values for the classification of SMD components with regard to their behavior in moisture (MSL – Moisture Sensitivity Level) and the resulting measures for packaging, storage, and handling. This is to ensure that damage caused by reflow soldering during production is avoided. The MSL and T_P values are used exclusively for product characterization and provide information about the robustness of semiconductor components in relation to the reflow soldering process. They define the time period during which components may be exposed to a controlled environment before an additional drying process is required prior to processing (soldering).

1.2 Maximum reflow conditions and cycles

Components classified in accordance with JEDEC standard J-STD 020F “Moisture/Reflow Sensitivity Classification for Non-hermetic Surface Mount Devices (SMDs)”, have been tested with three reflow cycles. Two times for double-sided assembly and one for rework. The maximum temperatures and conditions as specified in the data sheet must not be exceeded during assembly.

1.3 Vacuum soldering

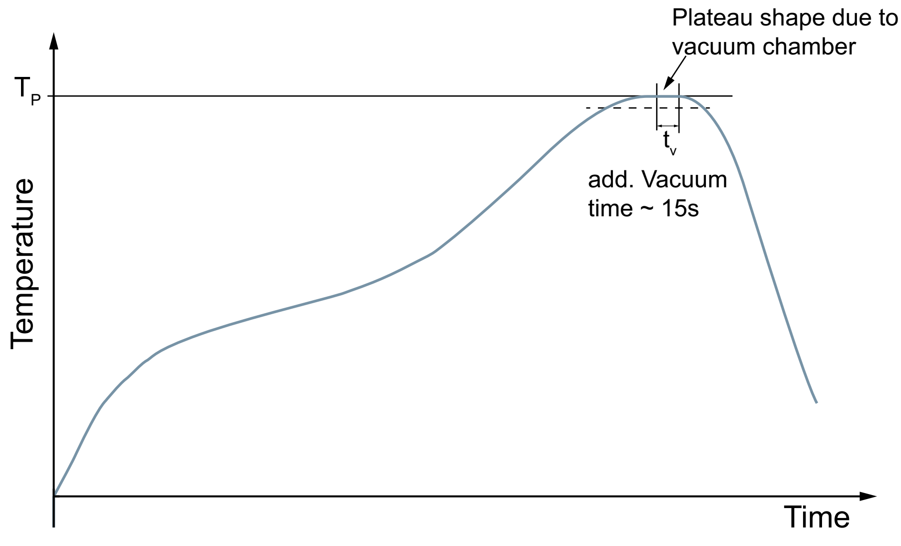
Voids are small bubbles of trapped gas or flux residue that form during the soldering process, typically within the bulk of the solder or at the interface with the substrate or component termination. Vacuum soldering is used in the industry in order to improve solder joint performance. It can minimize the void content in solder joints and therefore improve thermal connection, but also electrical contact and mechanical fixation.

For convection reflow soldering with vacuum there are two main parameters which need to be controlled, and therefore the pressure-time profile should be recorded in addition to the temperature profile:

- The vacuum level (min. pressure) and vacuum steps
- Holding time of the vacuum level in seconds

Vacuum is applied during convection reflow soldering above the liquidus temperature of the solder in the final peak heating zone. Due to this additional process step, the time t_L is extended by t_V (~ 15s) and a small plateau results at the peak area in the reflow profile (Figure 4). To reduce the voids the vacuum step must be finished before the solder begins to solidify in the subsequent cooling phase.

Figure 4: Reflow profile with additional vacuum time



A complete elimination of voids, especially on large thermal pads, is challenging. However, internal tests achieved an acceptable void level by using a convection N_2 reflow oven equipped with a vacuum chamber in the last reflow zone. In vacuum reflow ovens, peak temperatures and the temperature profile are limited because the vacuum chamber is integrated into the final peak zones 3 and 4. This is a limitation of the equipment and not of the LED itself.

1.4 Vapor phase soldering (VPS)

In vapor phase reflow soldering, or also described as condensation soldering, a liquid heat transfer medium with a high boiling point (e.g., 240°C) is used to heat the assembly evenly. The PCB is immersed in vapor zone, the vapor condenses on the entire surface and releases latent heat, melting the solder. The liquid film forms over the entire product during condensation. Therefore, the soldering process takes place in an oxygen-free environment. This method ensures uniform heating, minimizes overheating risks as the peak temperature is limited to the boiling point of the process liquid, and is therefore ideal for temperature-sensitive components. When the PCB leave the vapor zone the process liquid evaporates completely.

When profiling the vapor reflow soldering process, the maximum parameter limits specified in the product data sheet must be observed.

Tests showed that an excellent solder quality could be achieved also for high heat demanding applications, aluminum or copper based IMS boards, and high-power LEDs.

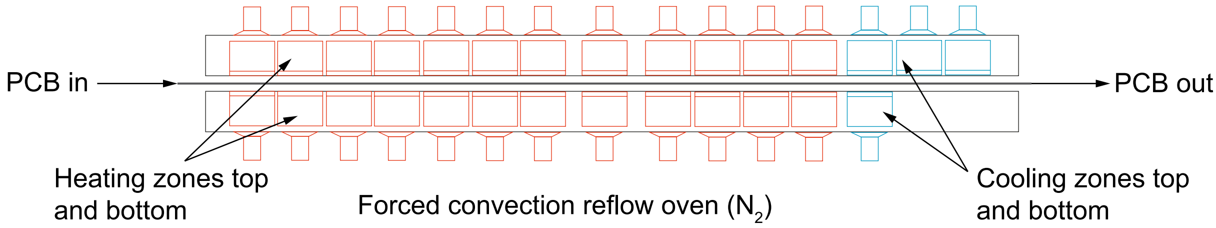
2 Reflow oven requirements

The reflow oven (Figure 5) is the central element of any soldering process and has the most significant influence on the solder quality. With the introduction of the RoHS directive and the associated higher operating temperatures, modern reflow ovens must meet increasingly stringent requirements. In addition to conventional processes, new soldering methods also need to be evaluated. The key objectives include:

- Precisely adjustable temperature profiles
- High repeatability
- Low energy consumption
- User-friendly operation
- Maximum throughput

The most critical factor is ensuring stable and uniform heat transfer to minimize temperature differences (ΔT) across the PCB. In modern convection reflow ovens, heat is transferred by circulating air or nitrogen, which is heated or cooled. Figure 5 illustrates a typical reflow oven with 12 heating and 3 cooling zones.

Figure 5: Schematic representation of a reflow oven with 12 heating and 3 cooling zones



The efficiency of energy transfer to the board depends on the gas flow rate. Due to the varying dimensions and masses of the components, it is essential to adjust the flow rate. At the same time, displacement or blowing away of components must be avoided.

Stability of the process zones — even with different oven loading — is obtained through:

- Separation of the individual heating zones
- Powerful heating elements
- Precise and fast temperature control

To ensure a stable soldering process, a reflow oven should have the following characteristics:

- Independently controlled heating zones (top and bottom)
- Flexible profile adjustment using as many heating zones as possible
- Non interference of temperature and flow from zone to zone
- Controlled flow and flow rate
- Uniform temperature and flow properties throughout the entire process
- No shadow effects
- No offsetting of components
- Rapid heat-up times
- Independently controllable cooling zones (top and bottom cooling)

3 Creating a stable temperature-profile

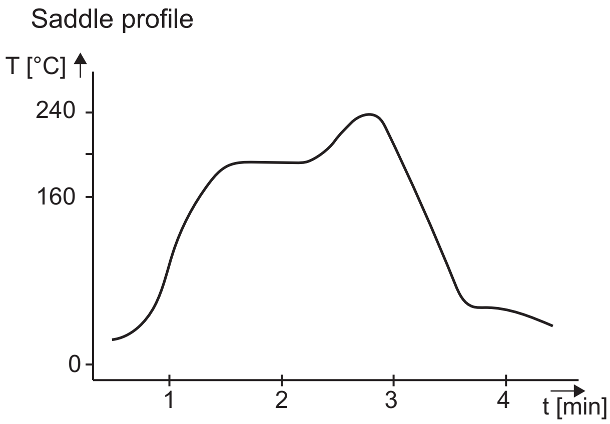
To achieve reliable soldering results, a reproducible temperature profile tailored to the respective product is required. This profile must consider multiple factors, including component types, solder paste characteristics, PCB design, and production conditions. Homogeneous heating is achieved through individually adjustable heating zones. The setup should prevent smaller components from overheating while providing sufficient heat for larger components.

Depending on component and solder paste, two basic profile types can be applied to determine the optimal settings (Figure 6). The temperature profile determines the heating at a specific point in time.

Saddle profile: With the saddle profile, the assembly is preheated in phases to the point at which the solder paste is activated. The temperature is then maintained so that the different thermal masses of the individual assemblies can adapt. Soldering then takes place in the subsequent short peak area.

Linear profile: With the linear profile, the assembly is heated up to the peak area with a uniform, relatively linear temperature increase.

Figure 6: Schematic temperature profile of a saddle and a linear profile



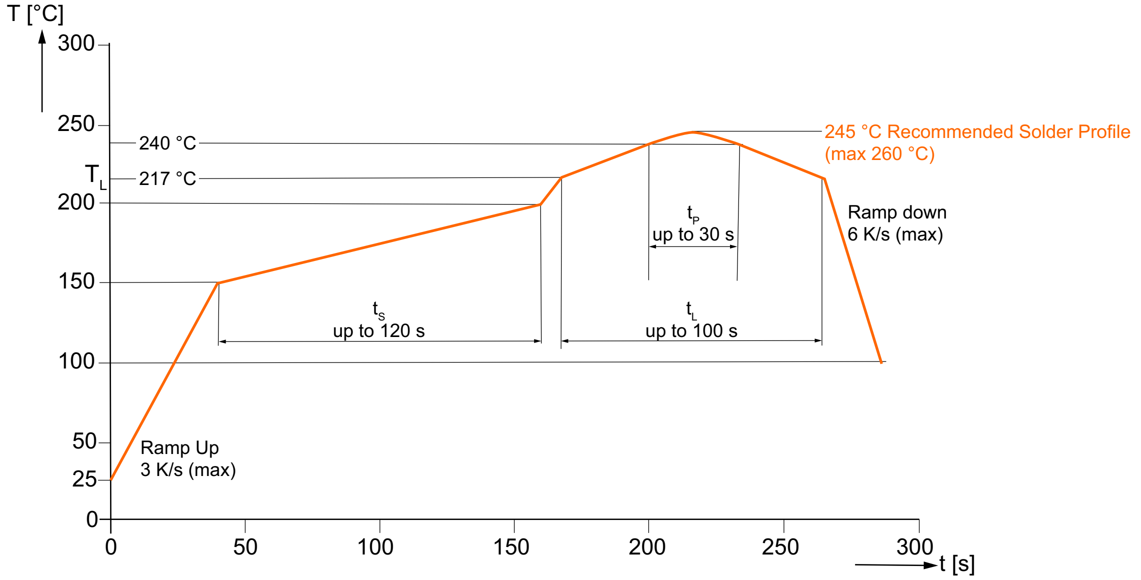
To create an ideal temperature profile for an electronic module, all influencing factors — such as solder paste, thermal mass, number and size of components, board design, PCB material and construction, and the soldering oven — should be known and considered (see application note "Measuring of the temperature profile during the reflow solder process").

The recommendations of the solder paste manufacturer should be used as a starting point for profiling. These typically include relevant parameters and limits for achieving optimal results. Information on PCB solderability is often unavailable, so an initial estimation can only be based on the material (FR4 or IMS), design (number of layers), and the wetting properties of the surfaces. Special attention must be given to the maximum load limits specified for SMD components. Manufacturers generally refer to standards such as JEDEC J-STD-020F, JEDEC J-STD-075, and IEC 60068-2-58.

3.1 Structure of a temperature-profile

Figure 7 shows a typical ams OSRAM temperature-time profile and table, listed in many product data sheets.

Figure 7: Recommended ams OSRAM temperature-time profile



Profile Feature	Symbol	Pb-Free (SnAgCu) Assembly			Unit
		Min	Recommended	Max	
Ramp-up rate to preheat[1] 25 °C to 150 °C			2	3	K/s
Time t_S $T_S$min to $T_S$max	t_S	60	100	120	s
Ramp-up rate to peak[1] T_{Smax} to T_P			2	3	K/s
Liquidus temperature	T_L		217		°C
Time above liquidus temperature	t_L		80	100	s
Peak temperature[3]	T_P		245	260	°C
Time within 5 °C of the specified peak temperature T_P - 5 K	t_P	10	20	30	s
Ramp-down rate[1] T_P to 100 °C			3	6[2]	K/s
Time 25 °C to T_P				480	s

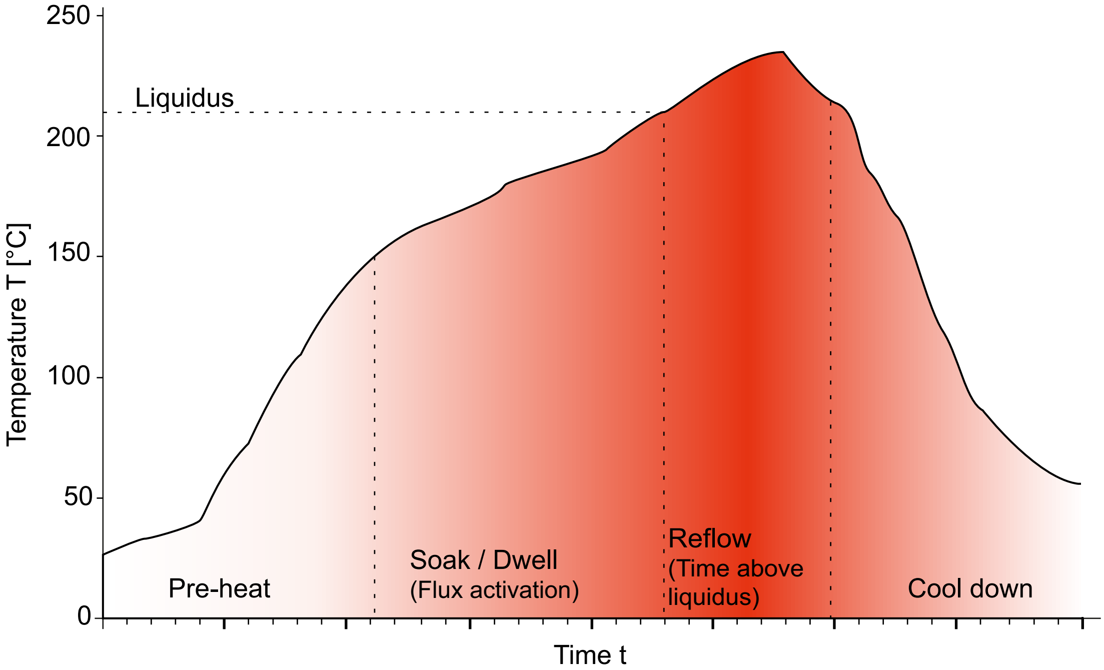
All the temperatures refer to the center of the package, measured on the top of the component
[1]slope calculation D_T/D_t: D_t max. 5 s; fulfillment for the whole T-range
[2]max cool down depending on temperature sensitivity
[3]Peak temperature depends on package thickness and volume for lead-free processing (see Table 2)

The most important parameters of a temperature profile are:

- Ramp-up gradient divided into two zones
  - Preheat: 25 °C to 150 °C
  - Ramp to peak: T_{smax} to T_P
- Soak time
- Time above liquidus t_L
- Peak temperature T_P
- Ramp down gradient
- Special characteristics (gradient jumps)

A temperature profile for SAC solder pastes (lead-free solder paste made of Tin, Silver, and Copper) can basically be divided into four phases (Figure 8).

Figure 8: The 4 phases of a temperature profile



Pre-heat

First, the circuit board, SMD components, and solder paste are heated to a specific temperature. Depending on the solder paste used, this is between 120°C and 150°C. At this temperature, the solvent and moisture in the solder paste evaporate. A maximum heating gradient of 3°C/s should not be exceeded. Faster heating can reduce the contour stability of the solder paste and increase the risk of solder balls formation. In addition, a higher heating gradient increases the risk of defects such as cracks and delamination on components and substrates.

Soak / Dwell

The soak time (also referred to as dwell time, solder paste dry phase, or activation phase) stabilizes the temperature as evenly as possible across the entire PCB. At the same time, this phase serves to activate the flux, which changes to a liquid state and cleans the surface to be soldered. Linear temperature profiles integrate the soak time into the pre-heating time.

Here, too, the JEDEC standard J-STD 020F specifies a time limit, and specific limit values and recommendations are listed in the solder paste data sheet.

If the soak time is too short, the flux may not be sufficiently activated, whereas too long a period will thermally destroy the chemical components of the flux. Both have a negative effect on the soldering result.

Reflow (Time above liquidus)

The reflow section (time above liquidus) is the period during which the melting and soldering process takes place (=reflow), also referred to as the peak zone. The heating rate is usually around 2°C/s up to the peak temperature TP, which should be 20 °C to 40 °C above the liquidus temperature. This liquidus temperature is 217 °C for standard SAC solder. The time above liquidus should be limited to 30-90 seconds to avoid excessive growth of intermetallic phases and dissolution effects. Exceeding the time or peak temperature can cause thermal damage and, in extreme cases, charring of the residues. Components and PCB substrates can also be affected.

Cool down

During the cool down, a cooling rate of 3 °C/s is recommended so that the material can cool evenly and stress is minimized, especially in the case of different thermal coefficients. Cooling rates that are too high or too low (≤ 0.5 °C/s, especially around the melting point) affect the reliability of the solder joint.

3.2 Ramp rates

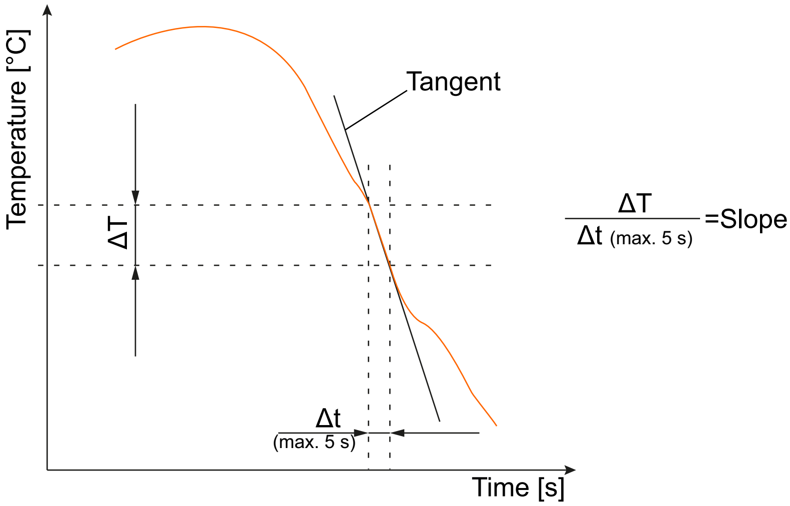
An important parameter for the evaluation and assessment of reflow profiles are the gradients in the heating and cooling phases. Figure 9 shows the recommended temperature-time curve as a basis for calculating the gradients. For a precise evaluation of a profile, it is necessary to determine the gradients over the entire reflow profile.

The following calculation basis is then used:

$$\frac{\Delta T}{\Delta t} = Slope$$ (Δt max. 5 sec. according to J-STD-020F)

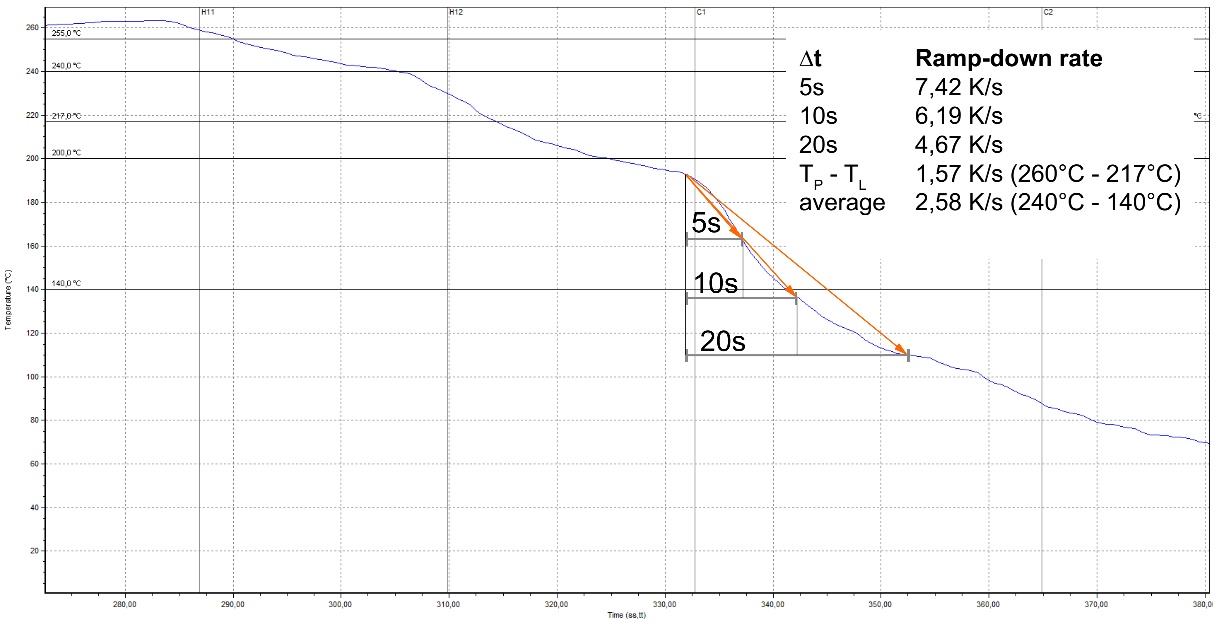
This formula should be used in both, heating (25 °C to T_P) and cooling (T_P to 100 °C) phases.

Figure 9: Gradient temperature-time curve for calculation



According to J-STD-020F, all ramp rates (both ramp-up and ramp-down) must be calculated as an average rate over a maximum 5 s period. It must not be single values nor overall averages across the entire profile. Selecting a suitable time window ensures that the real rates are captured, enabling a precise evaluation of the soldering profile. As illustrated in Figure 10, a longer time interval significantly affects the calculated ramp rate. This leads to a incorrect decision regarding the reflow profile.

Figure 10: Impact of time interval for gradient evaluation

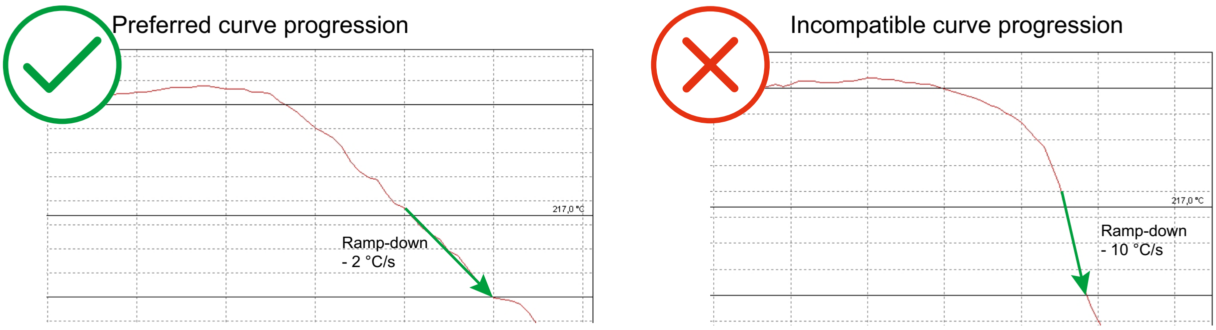


3.3 Possible measures for optimizing the reflow profile

As described, wrongly selected parameters and settings can cause substantial damage of the component to be soldered. The following references should assist and point out possibilities to optimize the reflow profile respectively to realize a LED friendly solder process as possible with few modifications.

- The peak temperature should be limited to approximately 240 °C (T_C)
- Linear heating should be maintained throughout the process
- Jumps in gradient should be avoided during transition from soak to reflow zones
- A uniform curve progression should be ensured around the peak temperature within the time interval above liquidus temperature (Figure 11)
- The last heating zone should be used for gentle cooling (approximately 170 °C)
- The operating point of the chiller should be increased for the active cooling zone (generally only possibly by equipment manufacturer)
- The fan speed in the cooling zone should be reduced to the minimal value
- The conveyor speed should be reduced (may require simultaneous temperature adjustments in all heating zones)

Figure 11: Examples of different curve progression for the period over liquidus temperature

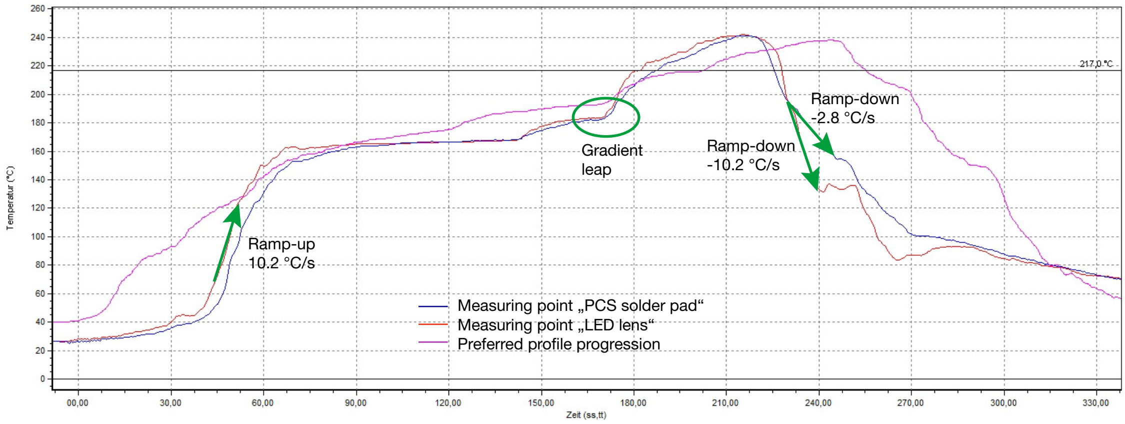


3.4 Example of a soldering profile that may cause problems

As an example, a soldering profile is shown below (Figure 12) that can be used to produce the error patterns described above. This real measured profile once again shows the large difference between the temperature on the solder pad and the temperature on the component package. Especially the large difference in the cooling gradients can be seen.

Both, extreme heating and cooling gradients, as well as a pronounced jump in gradient can cause soldering defects and/or excessive thermal stresses that lead to damage of the component.

Figure 12: Unsuitable reflow profile



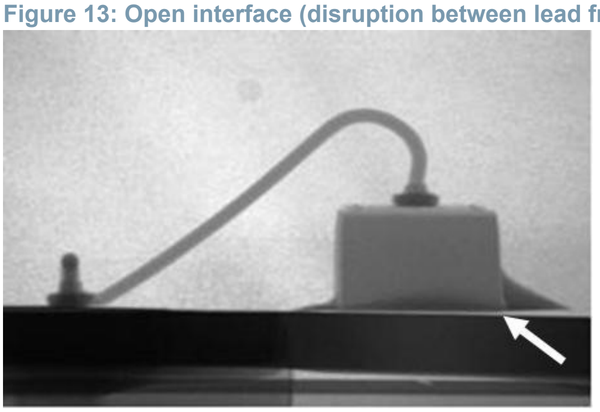
4 Reflow profile-dependent defect scenarios

Creating a reflow profile also includes factors such as optimized throughput and process-related requirements such as the lowest possible end temperature. These requirements can usually only be achieved by relatively high transport speeds in conjunction with higher peak temperatures or extreme cooling gradients in the cooling zone. As a result, the permissible thermal load limits of the components are often exhausted or even exceeded. This can lead to pre-damage or even spontaneous failure. Some examples of defects that can occur due to thermal overloading of the LEDs are shown in the following.

4.1 Open interface (die-adhesive-lead frame)

An open interface is an error caused by a thermo-mechanical overload (Figure 13) due to too high peak temperatures, too fast ramp up or / and extreme cooling gradients. The thermally induced tension to the LED is so high that the connecting point between lead frame and chip adhesive is torn open. In the X-ray image the detached chip including adhesive can be seen clearly.

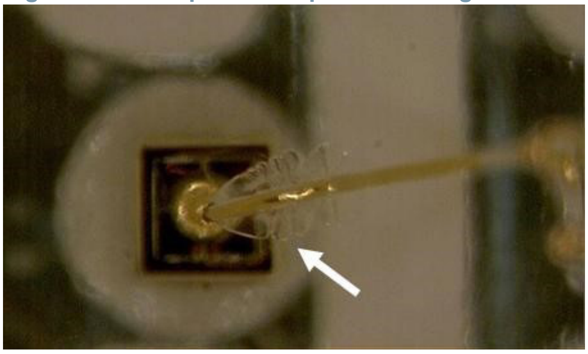
Figure 13: Open interface (disruption between lead frame and chip-glue)



4.2 Cracks

Delamination or cracks “Cobra cracks” (Figure 14) may cause the optical characteristics of the LED to be compromised. The delamination of the casting material to the leadframe or substrate of the LED housing and cracks in the epoxy material are also caused by extreme soldering profiles in combination with components that are processed with too high moisture content.

Figure 14: Example of component damage with crack



4.3 Tombstoning

A common solder defect, occurring primarily at small, usually two lead or chip components, is known as tombstoning. Here, due to unbalanced forces on the solder pads during the soldering process, the component is lifted on one side, so that no electrical contact to the solder pads can be formed on one connector pin.

When comparing saddle-type and linear profiles, the defect is observed more frequently with a saddle-type profile, as noted by Dr. Hans Bell in “Reflowfehler und Reflowprofile” (Rehm Thermal Systems GmbH, September 2007). This is due to the pronounced transition from the soak phase to the reflow phase (the molten state of the solder) in a saddle profile, which creates a sudden change in the temperature gradient. Such an abrupt temperature rise increases the risk of component damage. Additionally, the probability of tombstoning is strongly influenced by factors such as reflow oven atmosphere (air or nitrogen), transport speed, wetting characteristics of the solder pastes and asymmetrical solder pads. These factors always interact with each other.

4.4 Voiding

The formation of voids is usually caused by many different factors. In a lead-free reflow solder process the fluxes in the paste formulations have to operate at higher temperatures. Lead-free SAC alloys also have a higher surface tension than tin-lead. This increases the possibility that unwanted volatile substances will trap in the molten solder. These volatiles cannot escape easily, and voids are created when these compounds remain in the body of the solder once the material is solidified.

Standards like IPC-A-610 or J-STD-001 only refers to surface mount area array components like BGA. There the acceptable number of voids, verified by the x-ray pattern, should be less than 25%. But there are no specified acceptance criteria for QFN or Bottom only Terminated (BOT) components like LEDs.

As described in chapter 1.3 "Vacuum soldering" vacuum reflow soldering can reduce the void content in solder joints.

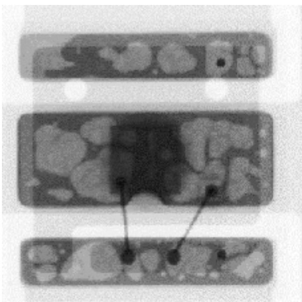
Based on industry studies and in-house experience at ams OSRAM, the following key recommendations can be summarized to optimize voiding:

- The solder paste type - particularly the properties of the flux - has a significant impact on wetting behavior and formation of voids. It is recommended to use pastes with good wetting characteristics and flux fluidity designed, ideally "low voiding pastes“.
- The surface metallization of the PCB affects the solder wetting. Depending on the material composition, the wetting behavior can vary. For consistently reliable wetting performance a NiAu finish is recommended.
- An important factor is the solder atmosphere. N_2 significantly improves wetting dynamics. Good results can be achieved by using O_2 < 500 ppm.
- The design of the stencil aperture. The recommended design with smaller multiple openings in the stencil enables an out-gassing of the solder paste during the reflow soldering process and also serves to regulate the final solder thickness. A typical solder paste coverage of 50 %–70 % is recommended.
- The reflow profile parameters should be optimized (common industry approach) by:
  - Increasing preheat time and temperature
  - Increasing time above liquidus (t_L) > 80sec

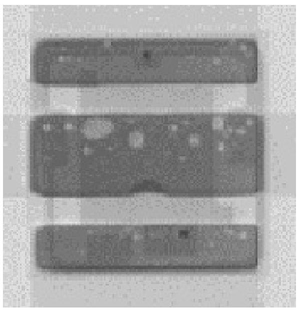
Figure 15 shows the same device soldered with two different process conditions: One using suboptimal settings, which results in a high void level. The other with optimized parameters, achieving a good and reliable solder joint.

Figure 15: Example of a solder joint with different process conditions

High void level



Good void level



5 Summary

Lead-free reflow soldering requires precise thermal management due to narrow process windows between melting point and component stress limits. The JEDEC J-STD 020F standard defines critical limits for temperature profiles and moisture sensitivity. A stable soldering process requires a reproducible profile that accounts for factors such as PCB material, component size, and solder paste properties. To achieve the optimum settings, it is necessary to apply all possible technological opportunities of the ovens.

The recommendations must always be adapted to the individual conditions and requirements of the boards and the manufacturing environment (oven, materials, etc.). The given parameters provide an orientation, but the evaluation of the solder joint is essential. Accordingly, the parameters may need to be optimized.

Additional techniques like vacuum or vapor-phase soldering can improve the solder joint quality by reducing voids. Also an uniform heat transfer and process stability. Typical defects such as tombstoning, cracks, or open interfaces often result from unsuitable profiles or excessive thermal stress. Careful optimization of the reflow profile minimizes these risks and ensures reliable electrical and mechanical connections.

The specified limits represent are absolute upper limits for the values tested in component qualification and should therefore not be used in the manufacturing process.

6 References and literature

- IPC/JEDEC J-STD-020F, Moisture/Reflow Sensitivity Classification for Non-hermetic Surface Mount Devices (SMDs), Dec 2022.
- JEDEC Publication No 140, Beaded Thermocouple Temperature Measurement of Semiconductor Packages
- IEC 60068-3-12 Supporting documentation and guidance – Method to evaluate a possible lead-free solder reflow temperature profile
- IEC 60068-3-15, Supporting documentation and guidance – Vacuum-assisted reflow soldering
- IPC 7801A, Reflow Oven Process Control Standard
- IPC 7530-B, Guidelines for Temperature Profiling for Mass Soldering Processes (Reflow and Wave)
- JEDEC J-STD-075, Classification of Non-IC Electronic Components for Assembly Processes
- Dr. Hans Bell, Reflowfehler und Reflowprofile, Rehm Thermal Systems GmbH, September 2007.
- Dr. Hans Bell, Reflowlöten Grundlagen, Verfahren, Temperaturprofile und Lötfehler, Eugen G. Leuze Verlag Bad Saulgau, ISBN 3-87480-202-7.
- P. John Shiloh and John Malboeuf, How to Profile a PCB, Novostar Technologies, 2005.

7 Glossary and Abbreviations

This glossary (Table 3) serves as a quick reference for critical terms and parameters discussed in this document. Table 4 provides the abbreviations.

Table 3: Glossary

Term	Description
Cooling Rate	The speed at which the assembly cools after the peak temperature.
JEDEC J-STD 020F	An industry standard defining moisture sensitivity levels and maximum reflow temperature limits for electronic components.
Lead-Free Soldering	Soldering using alloys without lead, typically based on tin, silver, and copper.
Liquidus Temperature	The temperature above which the solder alloy is completely liquid.
Peak Temperature	The highest temperature reached during the reflow cycle, critical for proper solder melting without damaging components.
Ramp Rate	The speed at which temperature increases during the heating phase of the reflow process.
Reflow Soldering	A process where solder paste is melted to create electrical and mechanical connections between components and the PCB.
SAC solder paste	Lead-free solder paste made of Tin, Silver, and Copper.
Soak Zone	A controlled temperature range before reaching the peak, allowing uniform heat distribution and activation of flux.
Time above liquidus	The duration which the solder alloy remains above its liquidus temperature (the point at which the alloy becomes fully molten). Abbreviated as t_L or as TAL.
Tombstoning	Component lifts during reflow.
Vacuum Reflow	A technique applying vacuum during reflow.
Vapor Phase Soldering	A soldering method using a controlled vapor environment.
Voids	Air pockets or gaps within the solder joint.

Table 4: Abbreviation list

Abbreviation	Description
JEDEC	Joint Electron Device Engineering Council
MSL	Moisture Sensitivity Level
PCB	Printed Circuit Board
PPT	Peak package body temperature
RoHS	Restriction of Hazardous Substances
SMD	Surface-Mount Device
t_L or TAL	Time above liquidus

ABOUT ams OSRAM Group (SIX: AMS)

The ams OSRAM Group (SIX: AMS) is a global leader in intelligent sensors and emitters. By adding intelligence to light and passion to innovation, we enrich people's lives. With over 110 years of combined history, our core is defined by imagination, deep engineering expertise and the ability to provide global industrial capacity in sensor and light technologies. Our around 20,000 employees worldwide focus on innovation across sensing, illumination and visualization to make journeys safer, medical diagnosis more accurate and daily moments in communication a richer experience. Headquartered in Premstaetten/Graz (Austria) with a co-headquarters in Munich (Germany), the group achieved EUR 3.6 billion revenues in 2023. Find out more about us on https://ams-osram.com

For further information on our products please see the Product Selector and scan this QR Code.

Published by ams-OSRAM AG
Tobelbader Strasse 30, 8141 Premstaetten, Austria

Published by ams-OSRAM AG
Tobelbader Strasse 30,
8141 Premstaetten Austria
Phone +43 3136 500-0
ams-osram.com